Ground Data System Support for ATLO & Launch/Cruise for NASA's 2011 Mars Science Laboratory (MSL)

Ground Data System Manager
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MSL ATLO System Engineer
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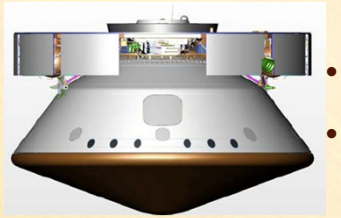
Background – Mission Objective & Capabilities

Explore and quantitatively assess a local region on Mars' surface as a potential habitat for life, past or present.

- **A long-lived, roving, robotic laboratory capable of visiting many sites**
- **Access to a wide range of candidate landing sites assessed by orbiting spacecraft**
- **A broad and flexible payload including advanced geochemical instruments used in Earth labs**

LAUNCH
From KSC

- Nov. 25th 2011
- Atlas V (541)

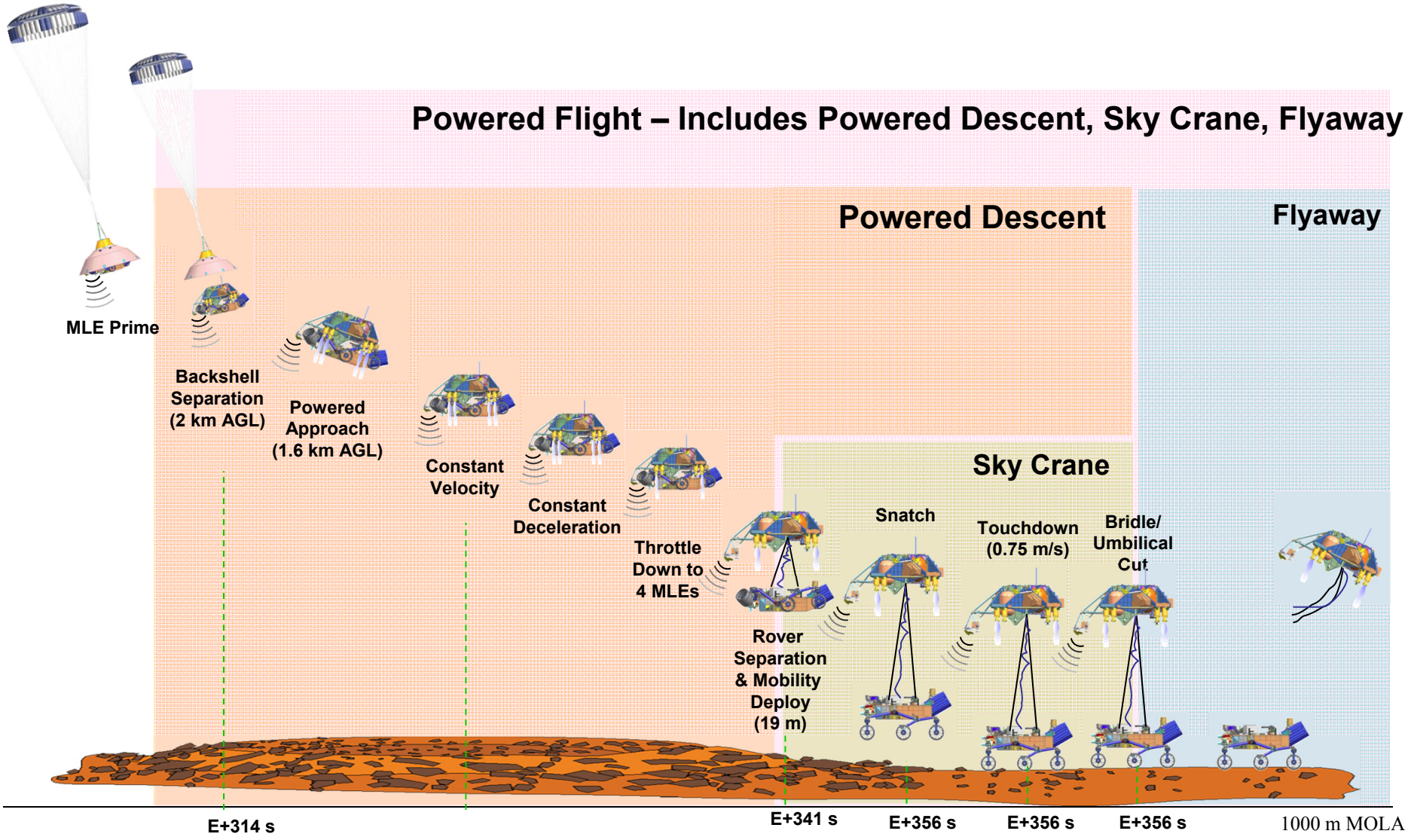


- 9 month cruise
- Spinning cruise stage

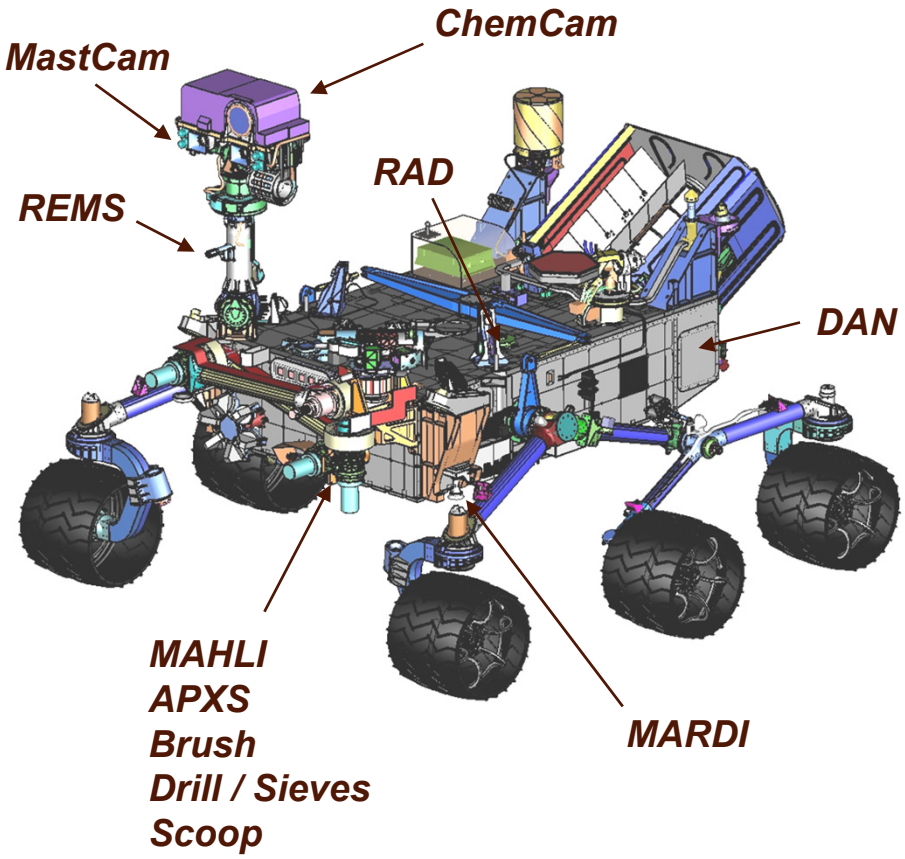
ENTRY, DESCENT, LANDING

- Guided entry and controlled, powered "sky crane" descent
- 20-km diameter landing ellipse
- Discovery responsive for landing sites ±45º latitude, <+1 km elevation
- 900-kg landed mass

Background - EDL Timeline



Background - MSL Payload



Wheel Base:	**2.2 m**
Height of Deck:	**1.1 m**
Height of Mast:	**2.2 m**

REMOTE SENSING

MastCam (M. Malin, MSSS) - Color stereo imaging, atmospheric opacity

ChemCam (R. Wiens, LANL/CNES) – Chemical composition; remote micro-imaging

CONTACT INSTRUMENTS (ARM)

MAHLI (K. Edgett, MSSS) - Microscopic imaging

APXS (R. Gellert, U. Guelph, Canada) - Chemical composition

ANALYTICAL LABORATORY (ROVER BODY)

SAM (P. Mahaffy, GSFC/CNES) - Chemical and isotopic composition, including organics

CheMin (D. Blake, ARC) - Mineralogy

ENVIRONMENTAL CHARACTERIZATION

MARDI (M. Malin, MSSS) - Descent imagery

REMS (J. Gómez-Elvira, CAB, Spain) - Meteorology / UV

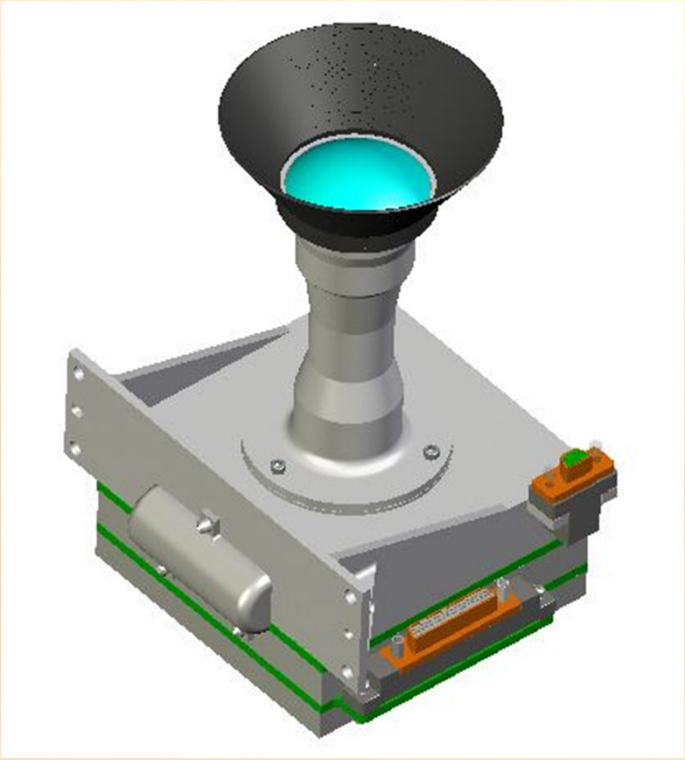
RAD (D. Hassler, SwRI) - High-energy radiation

DAN (I. Mitrofanov, IKI, Russia) - Subsurface hydrogen

Background - Mars Descent Imager (MARDI)

Principal Investigator: Michael Malin

Malin Space Science Systems



MARDI provides detailed imagery of the MSL landing region

- Provides images over three orders of magnitude in scale, tying post-landing surface images to pre-landing orbital images
- Bayer pattern filter for natural color
- Short exposure time to reduce image blurring from spacecraft motion
- High-definition, video-like data acquisition (1600×1200 pixels, 5 frames/sec)
- Large internal storage: 256 MByte SRAM, 8 GByte flash

Background - Sample Analysis at Mars (SAM)

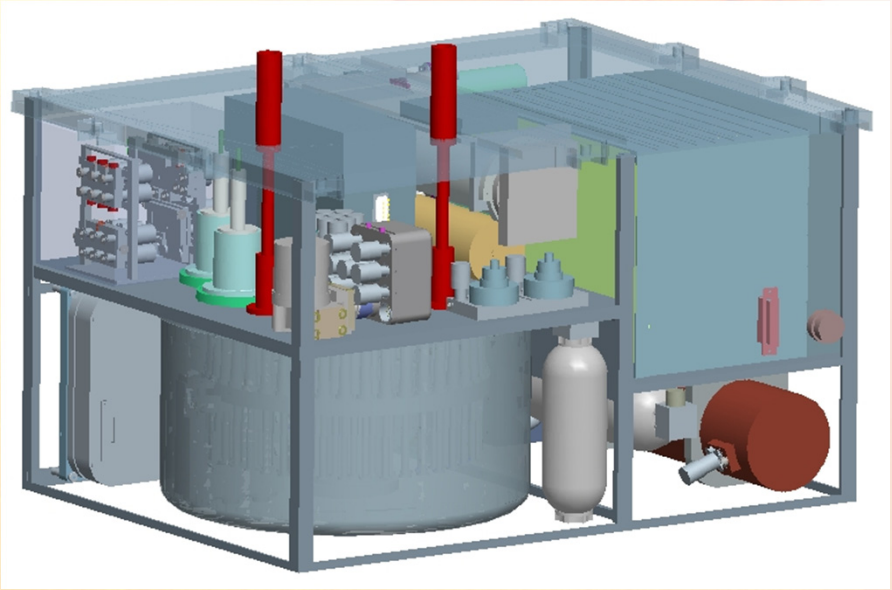
Principal Investigator: Paul Mahaffy

NASA Goddard Space Flight Center

SAM Suite Instruments

Quadrupole Mass Spectrometer (QMS)
Gas Chromatograph (GC)
Tunable Laser Spectrometer (TLS)

- Search for organic compounds of biotic and prebiotic relevance, including methane, and explore sources and destruction paths for carbon compounds
- Reveal chemical state of other light elements that are important for life as we know it on Earth
- Study the habitability of Mars by measuring oxidants such as hydrogen peroxide
- Investigate atmospheric and climate evolution through isotope measurements of noble gases and light elements



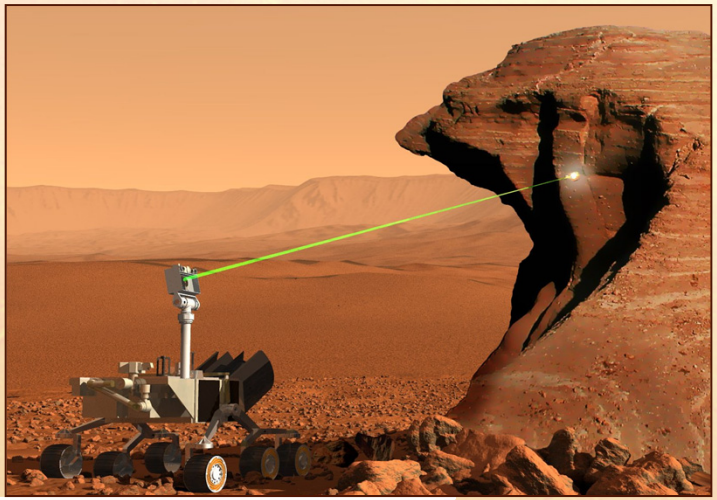
- **QMS:** molecular and isotopic composition in the 2-535 Dalton mass range for atmospheric and evolved gas samples
- **GC:** resolves complex mixtures of organics into separate components
- **TLS:** abundance and precision (<10 per mil) isotopic composition of CH_4, CO_2

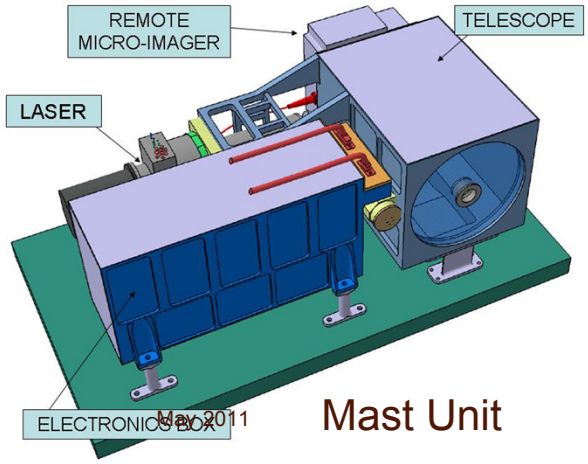
Background - Chemistry & Micro-Imaging (ChemCam)

Principal Investigator: Roger Wiens

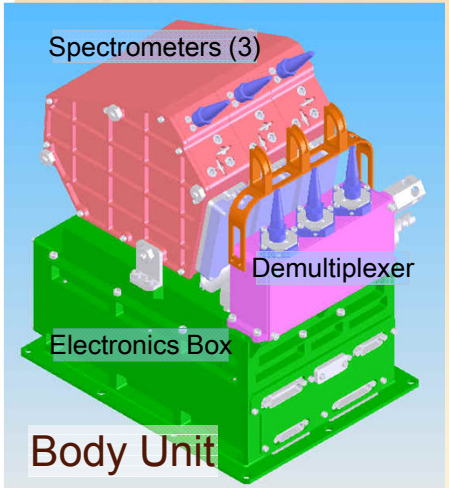
Los Alamos National Laboratory

Centre d'Etude Spatiale des Rayonnements





Mast Unit

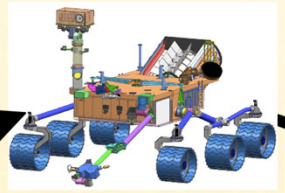


Body Unit

ChemCam performs elemental analyses through laser-induced breakdown spectroscopy

- Rapid characterization of rocks and soils from a distance of up to 9 meters
- 240-800 nm spectral range
- Dust removal over a ~1-cm region; depth profiling within a ~1-mm spot
- Helps classify hydrated minerals, ices, organic molecules, and weathering rinds
- High-resolution context imaging (resolves ~0.8 mm at 10 m)

MSL Ground Data System (partial)



Radiate Cmd/Seq to MSL (Direct or via Relay) **DSN Cmd**

DSN Tlm Acquire, Process, Store, Distribute Telemetry and Radiometric Data

MPCS Raw Data Product Gen, Channel Process, Report Gen

SEQGEN Sequence Validation & Translation

Sequence Editing **RSVP**

Plan Checking **Europa2**

MSLICE Activity Planning

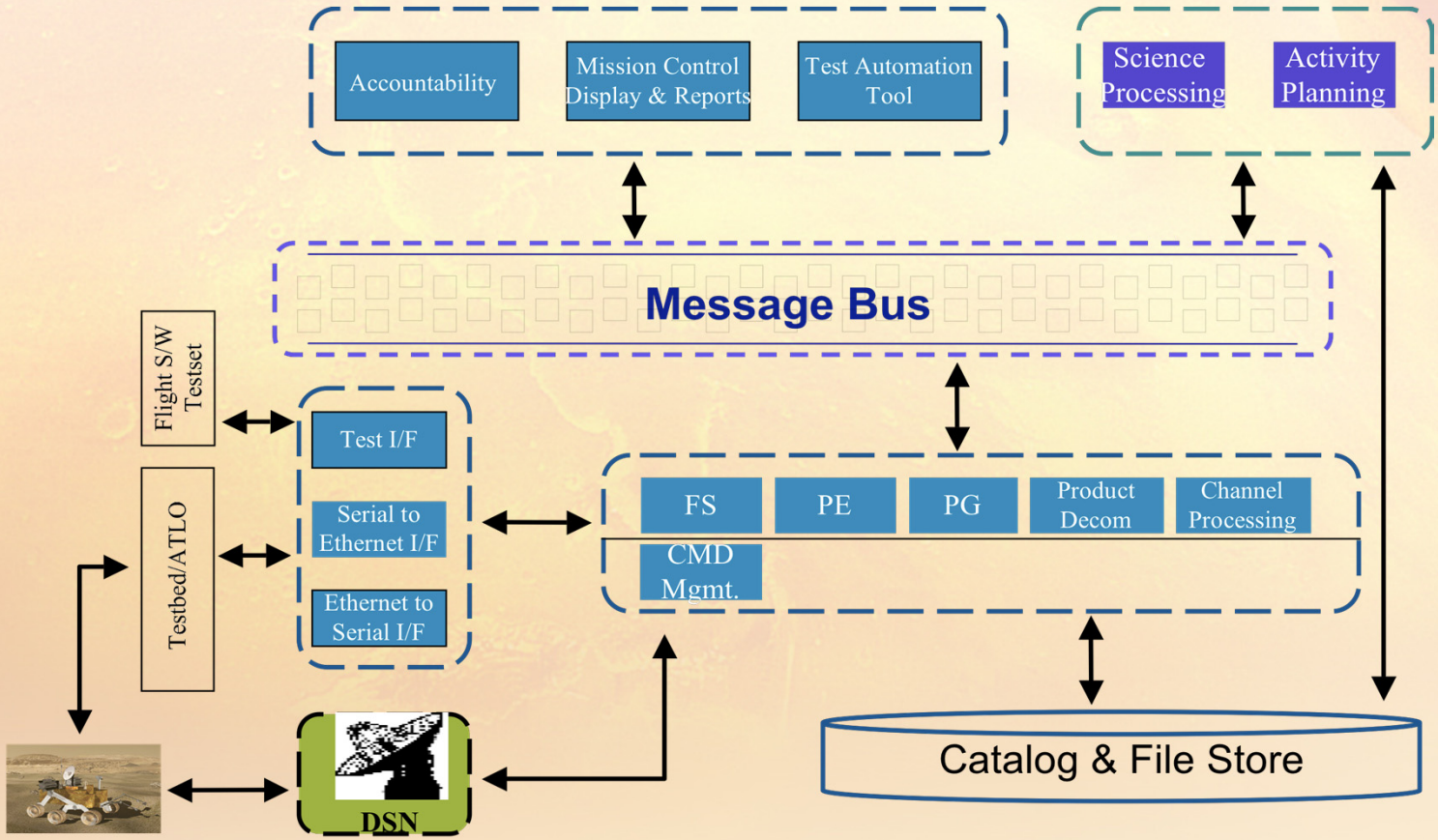
MIPL L0 for all Science; Tactical Image Process

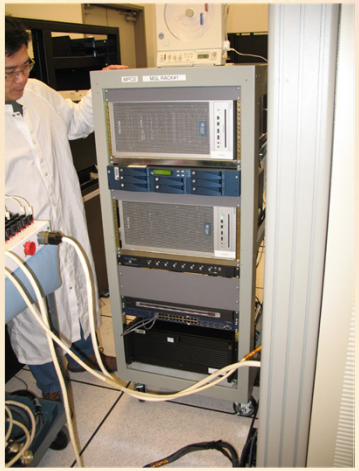
EAS Tools
Monitor and Analyze S/C Safety, Health, and Performance - Archive eng

Instrument GDSs
Monitor and Analyze Inst Safety, Health, and Performance - Archive sci

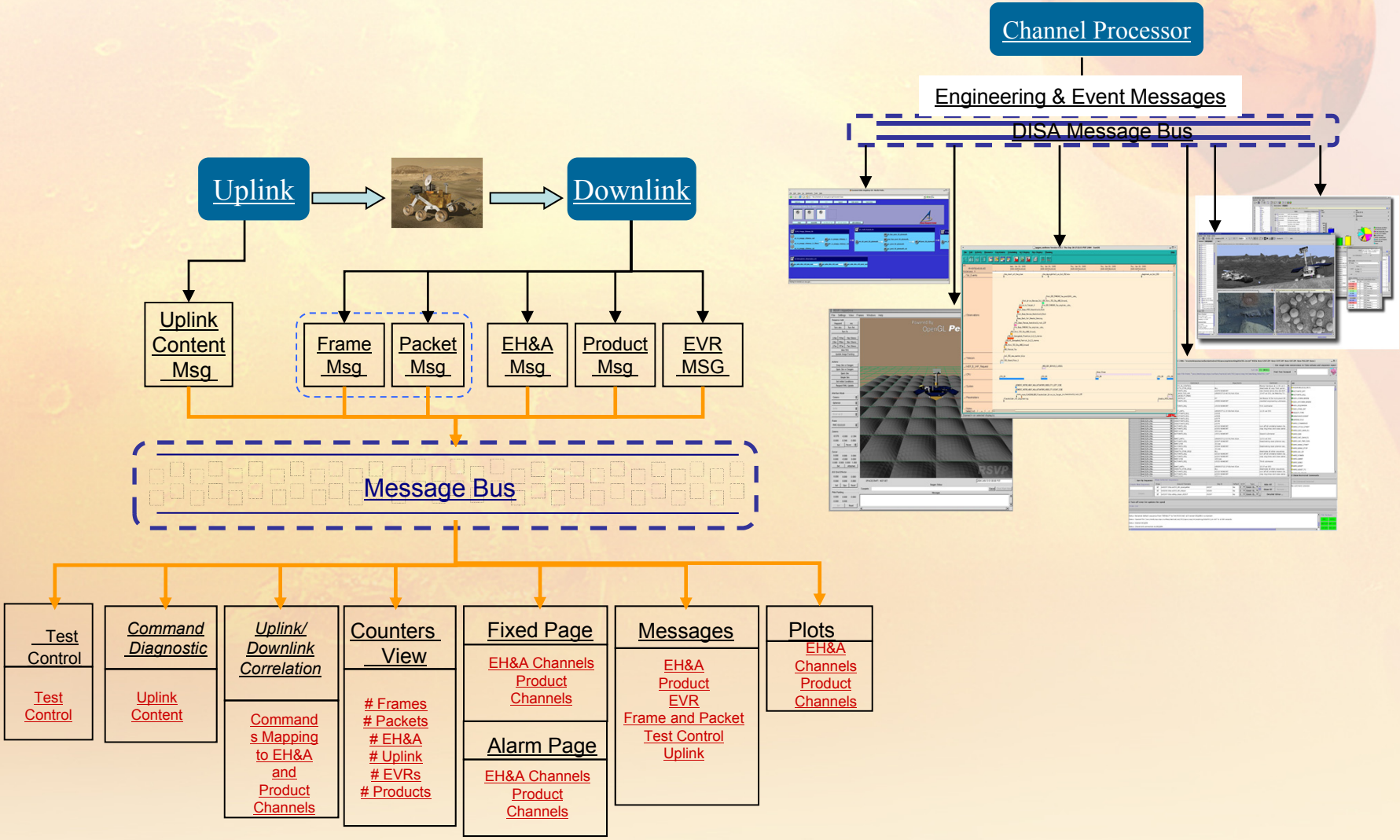
RSVP – Rover Sequencing and Visualization Program
MSLICE – Mars Science Laboratory Interface
SEQGEN – Sequence Generation
MPCS - Mission data Processing and Control System
MIPL – Multi-Mission Image Processing Laboratory

MPCS Architecture

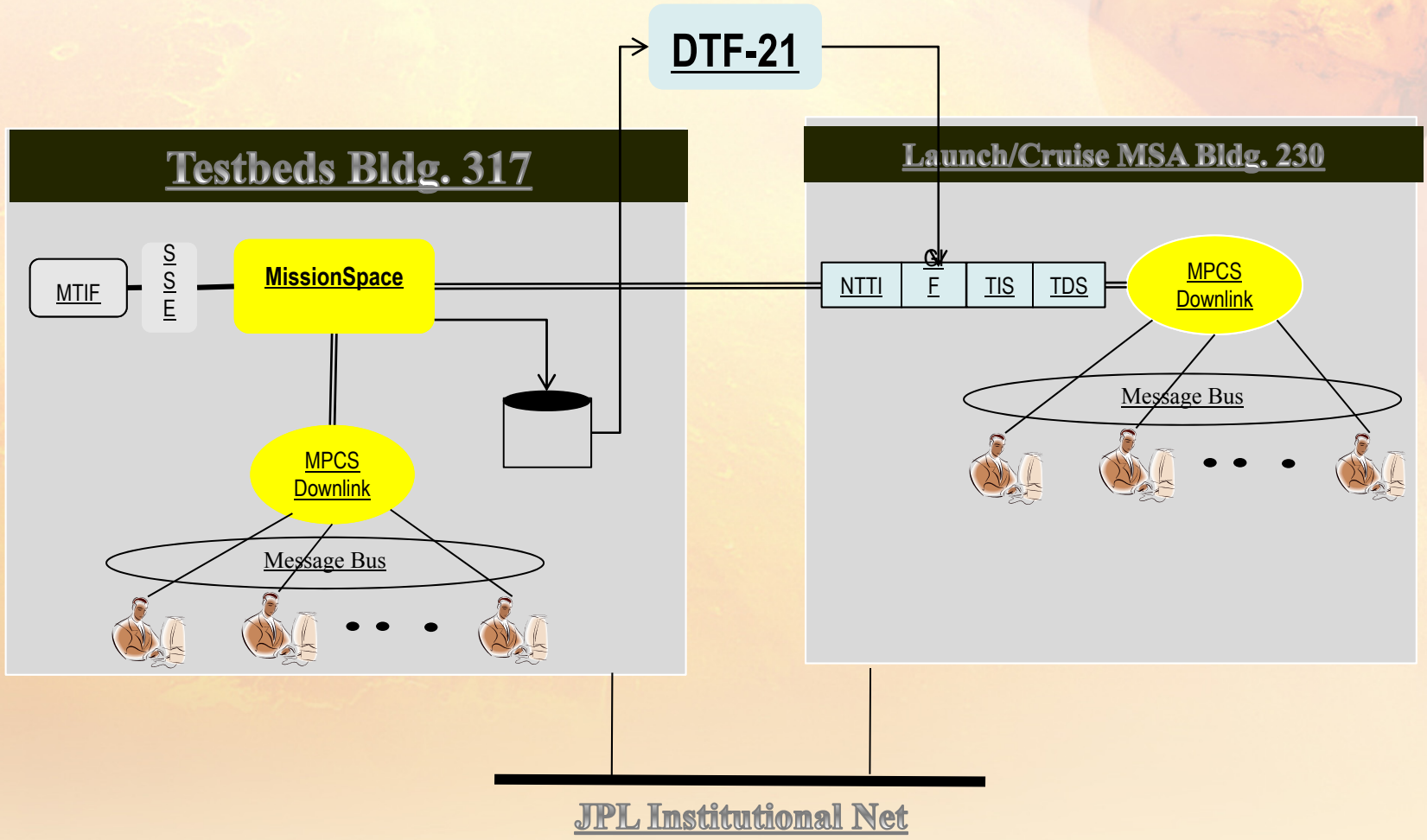




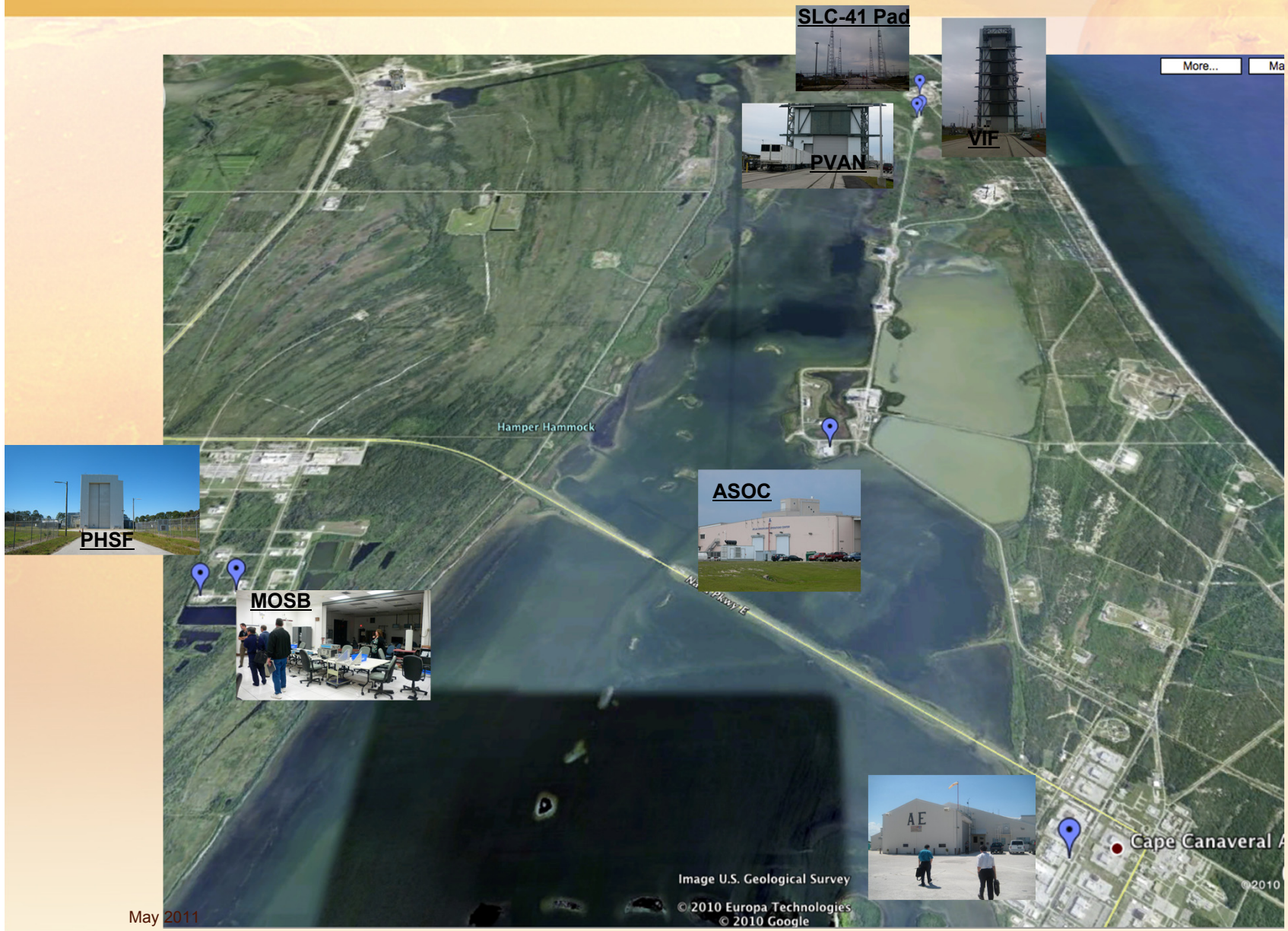
MPCS Use of Message-based Architecture and application to KSC Interface



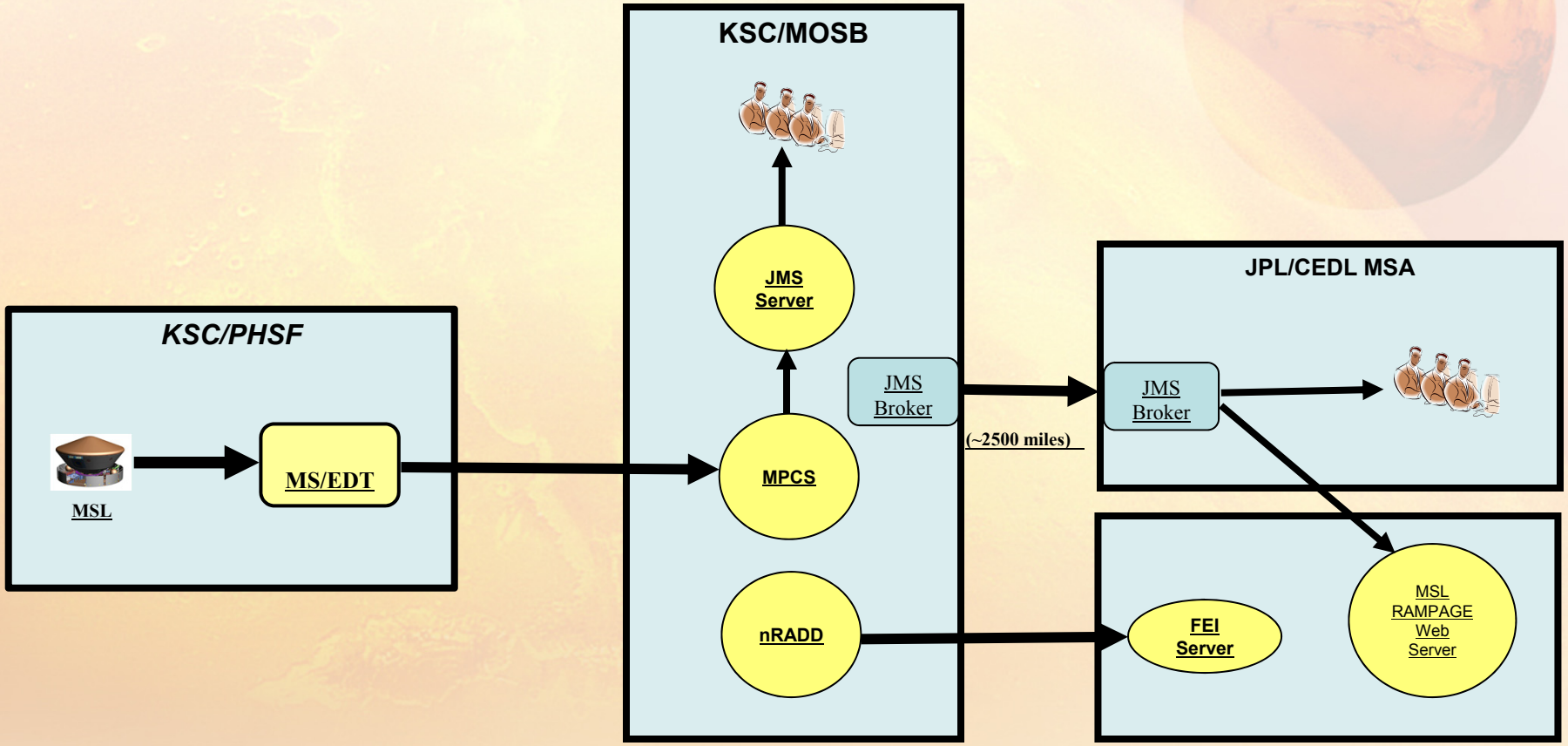
Testbed/MSA Dataflow



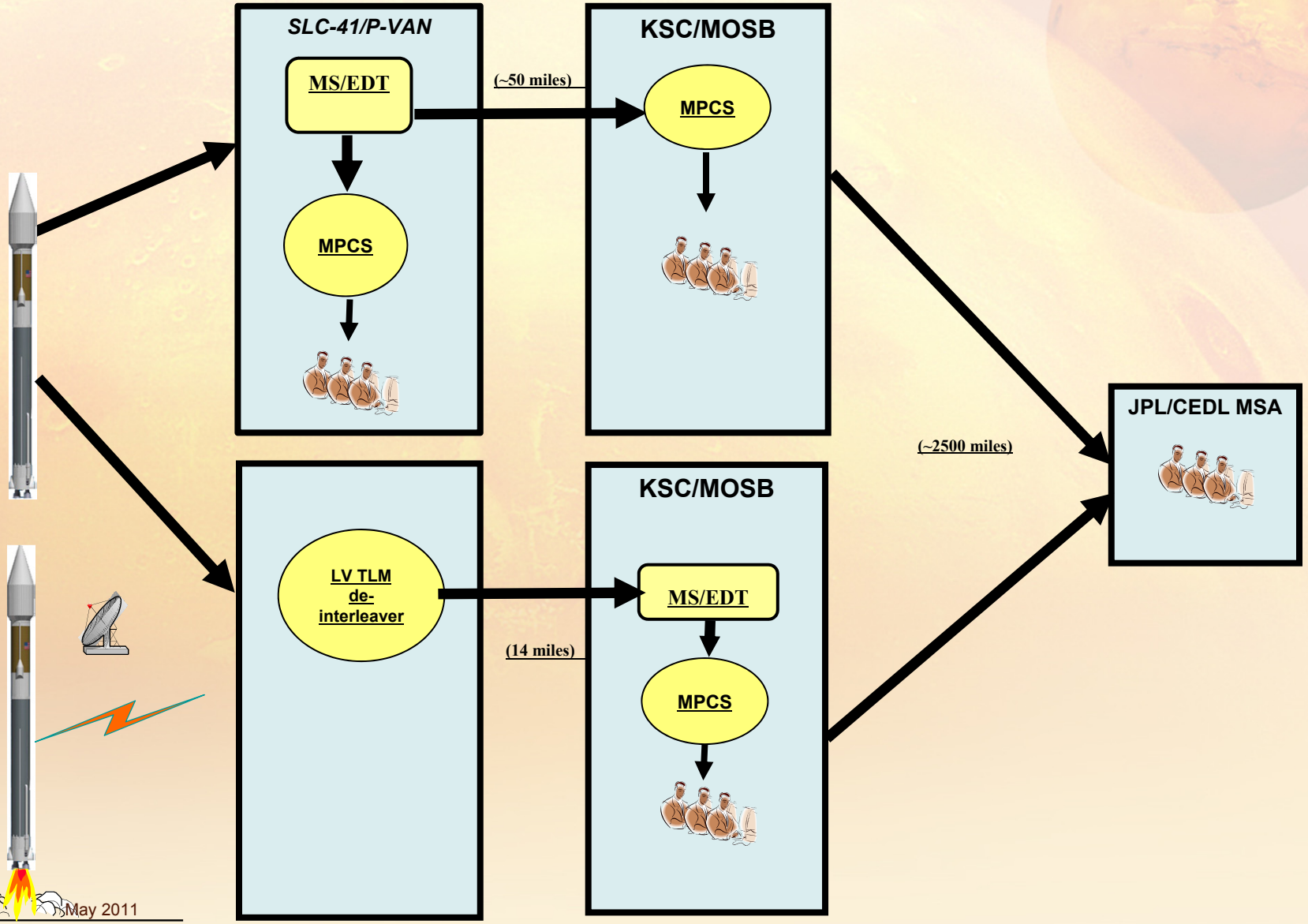
KSC Locations at a Glance



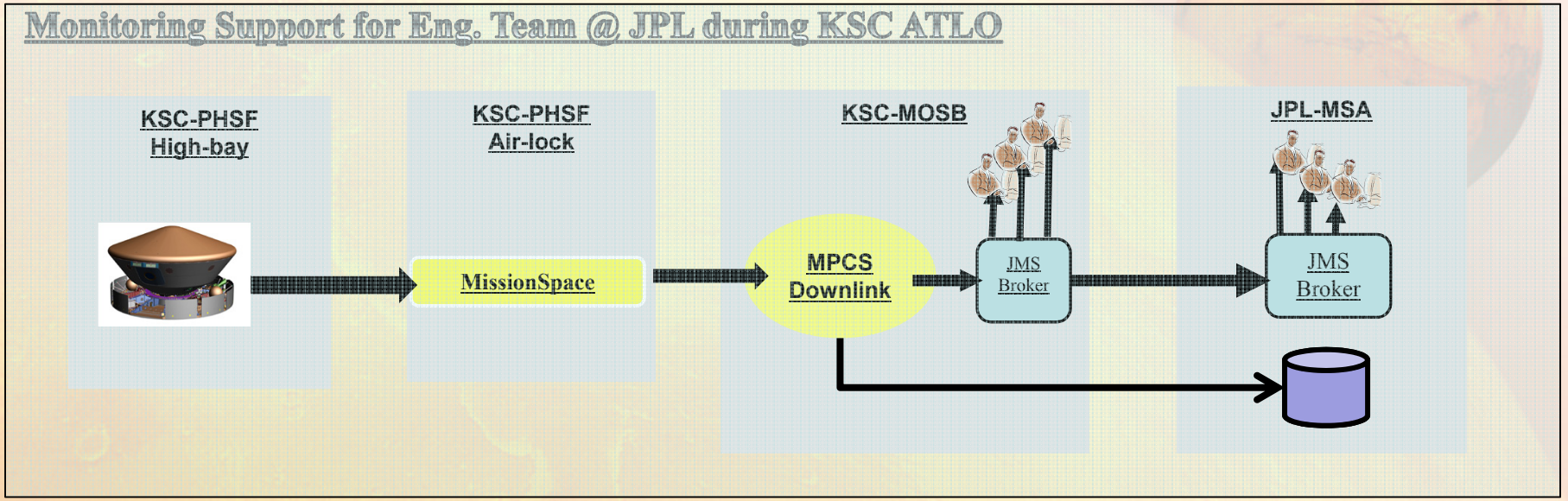
KSC/JPL TLM Dataflow

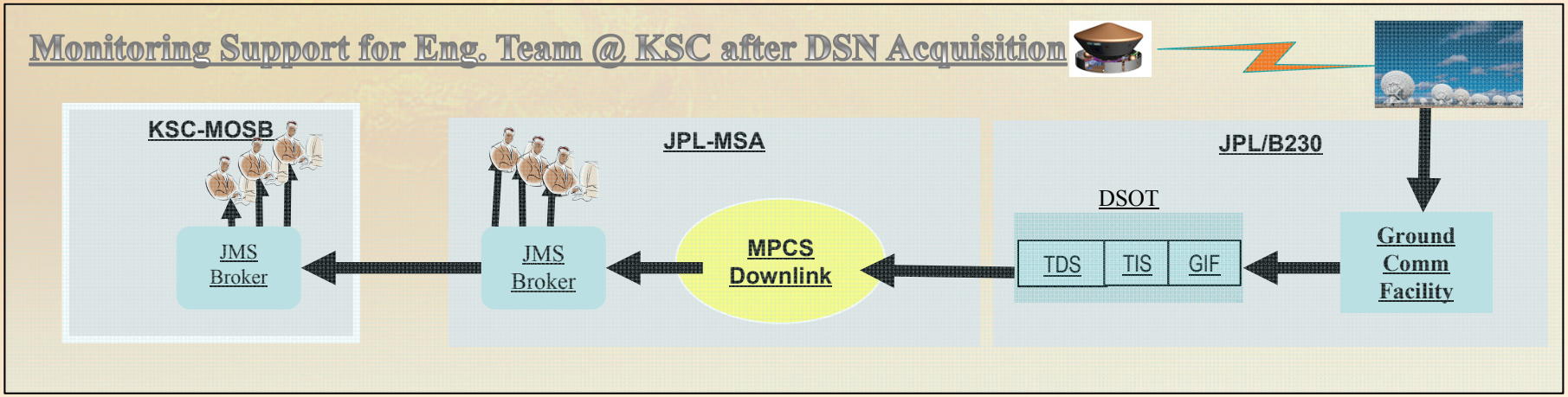


Phase 2: Pre-launch Check-out TLM Dataflow



KSC/JPL Interface



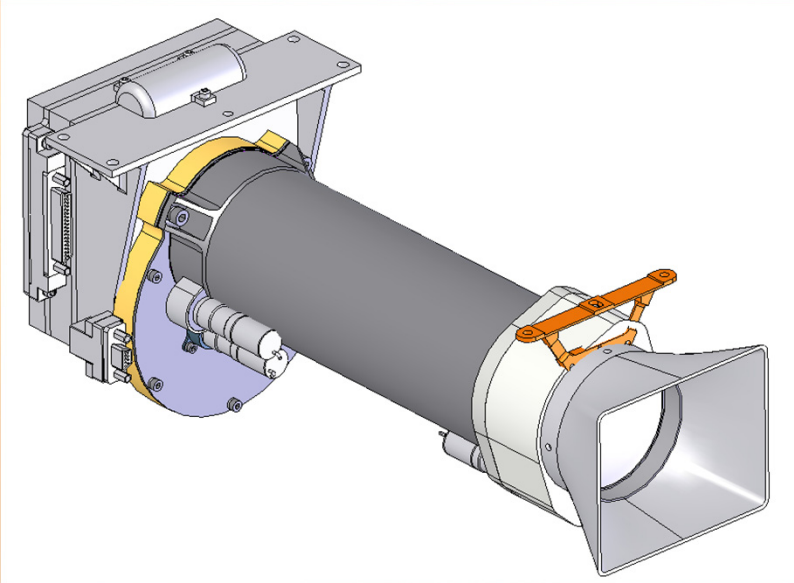


Backups

Mast Camera (MastCam)

Principal Investigator: Michael Malin

Malin Space Science Systems



MastCam observes the geological structures and features within the vicinity of the rover

- Studies of landscape, rocks, fines, frost/ice, and atmospheric features
- Stereo, 15:1 zoom/telephoto lens, from 90° to 6° FOV
- Bayer pattern filter design for natural color plus narrow-band filters for scientific color
- High spatial resolution: 1200×1200 pixels (0.2 mm/pixel at 2 m, 8 cm/pixel at 1 km)
- High-definition video at 5-10 FPS, 1280×720 pixels
- Large internal storage: 256 MByte SRAM, 8 GByte flash

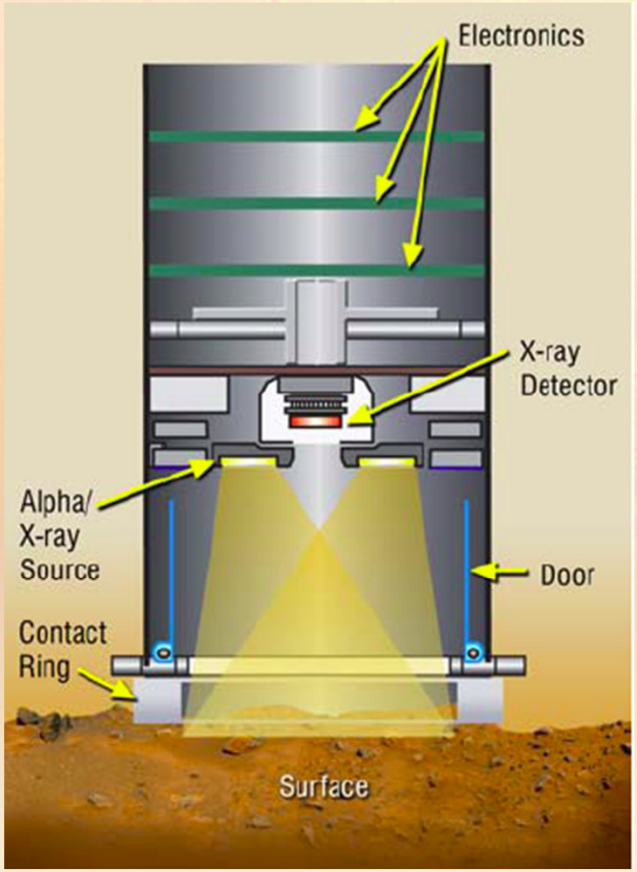
Alpha Particle X-Ray Spectrometer (APXS)

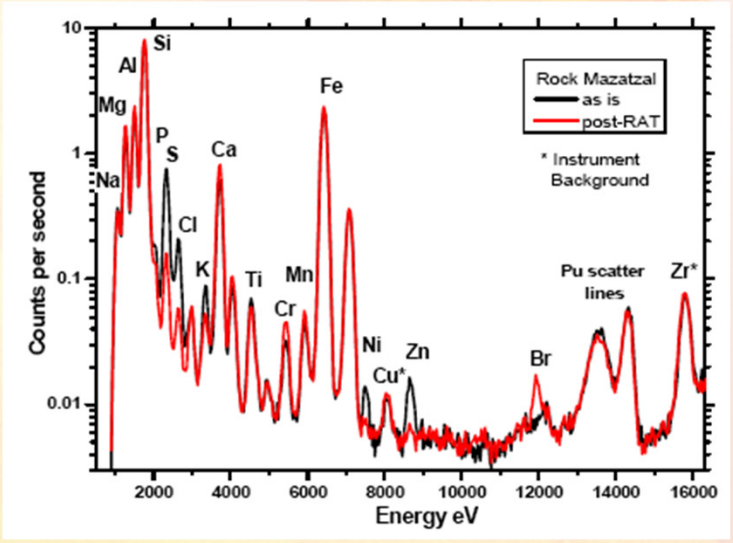
Principal Investigator: Ralf Gellert

University of Guelph, Ontario, Canada

Canadian Space Agency

Heritage: Pathfinder, MER





APXS determines the chemical composition of rocks, soils, and processed samples

- Combination of particle-induced X-ray emission and X-ray fluorescence using a ^{244}Cm source
- Rock-forming elements from Na to Br and beyond
- Useful for lateral / vertical variability, surface alteration, detection of salt-forming elements
- Factor ~3 increased sensitivity, daytime operation compared with MER

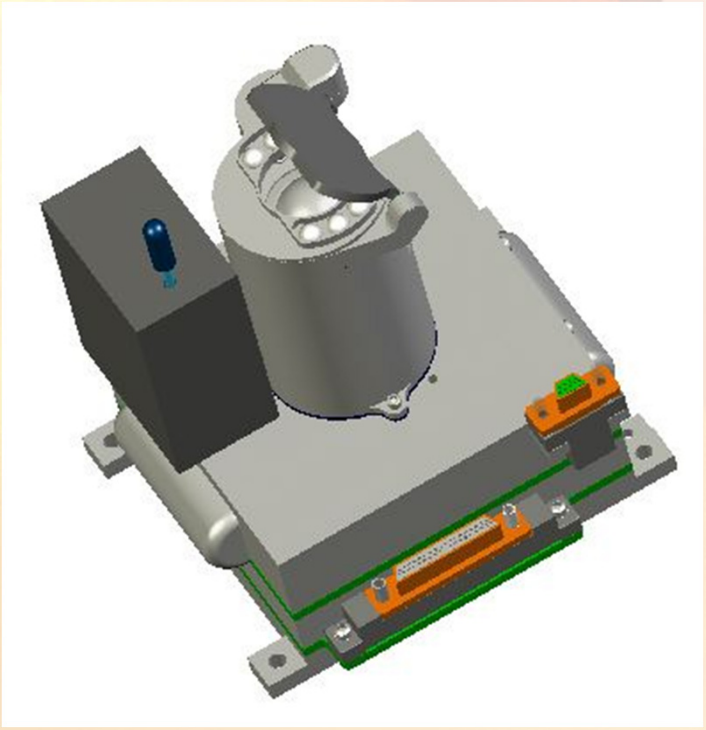
Mars Hand Lens Imager (MAHLI)

Principal Investigator: Kenneth Edgett

Malin Space Science Systems

MAHLI characterizes the history and processes recorded in geologic materials encountered by MSL

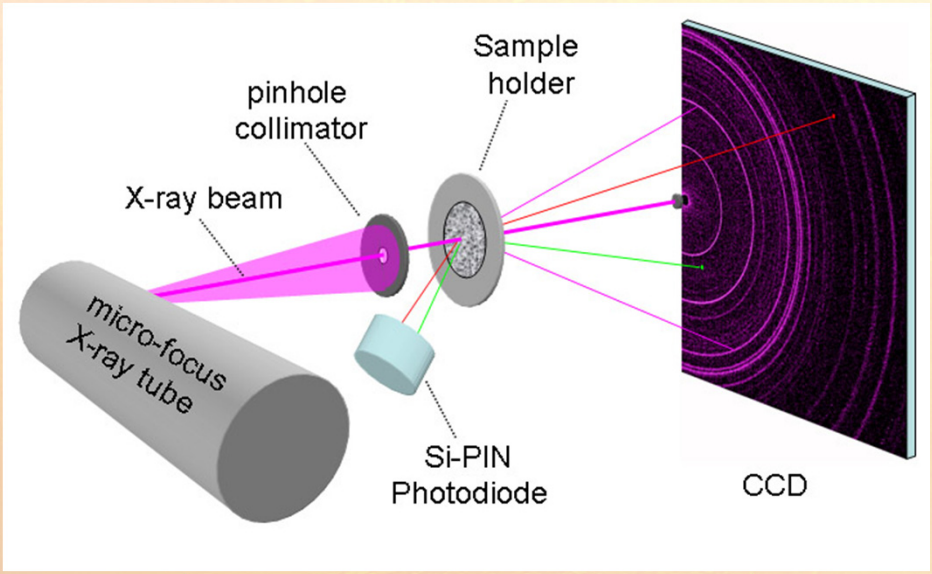
- Examines the structure and texture of rocks, fines, and frost/ice at micrometer to centimeter scale
- Returns color images like those of typical digital cameras; synthesizes best-focus images and depth-of-field range maps
- Wide range of spatial resolutions; can focus at infinity; highest spatial resolution possible is ~9 μm/pixel
- White light and UV LEDs for controlled illumination, fluorescence

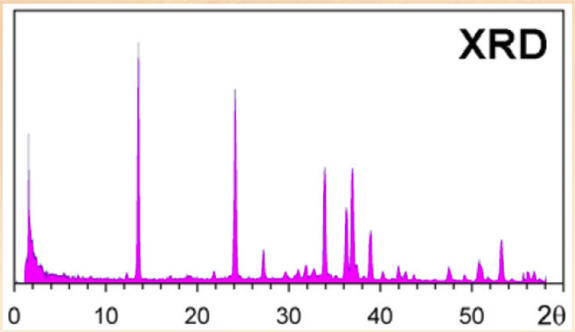


Chemistry & Mineralogy (CheMin)

Principal Investigator: David Blake

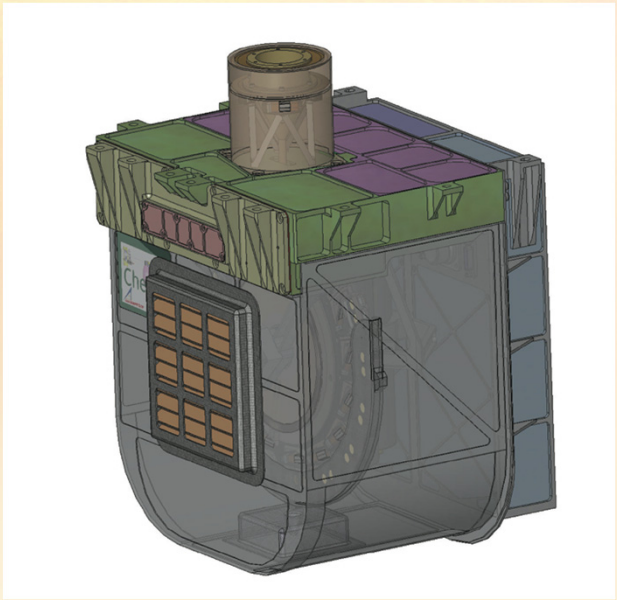
NASA Ames Research Center





CheMin derives definitive mineralogy

- X-ray diffraction (XRD); standard technique for laboratory analysis
- Identification and quantification of minerals in geologic materials (e.g., basalts, evaporites, soils)



Dynamic Albedo of Neutrons (DAN)

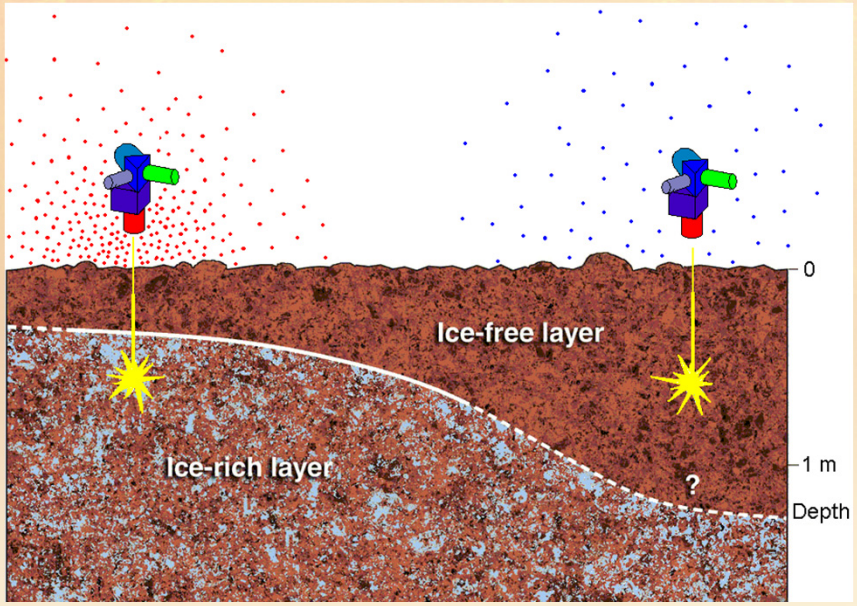
Principal Investigator: Igor Mitrofanov

Space Research Institute (IKI), Russia

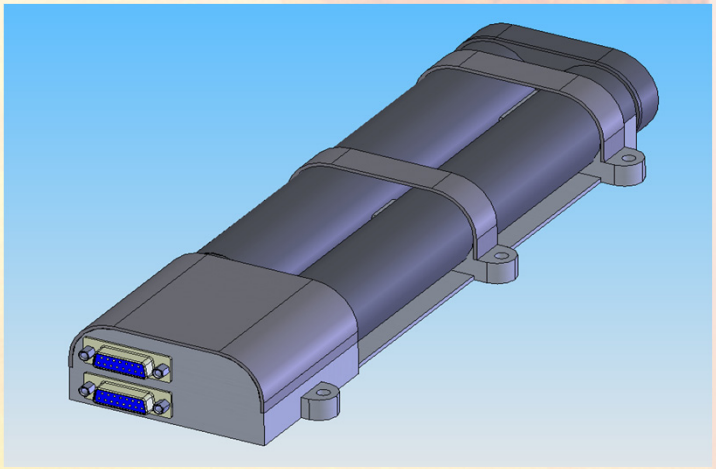
DAN measures the abundance of hydrogen (e.g., in water or hydrated minerals) within one meter of the surface

Large albedo flux of thermal neutrons

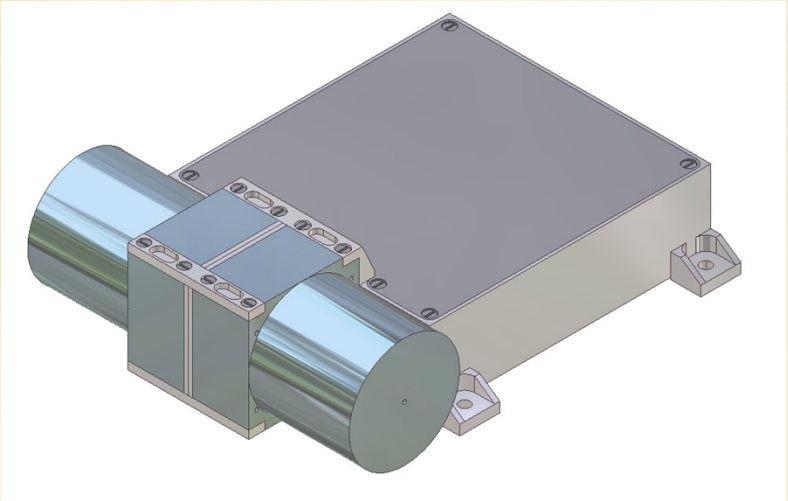
Small albedo flux of thermal neutrons



Pulsing Neutron Generator



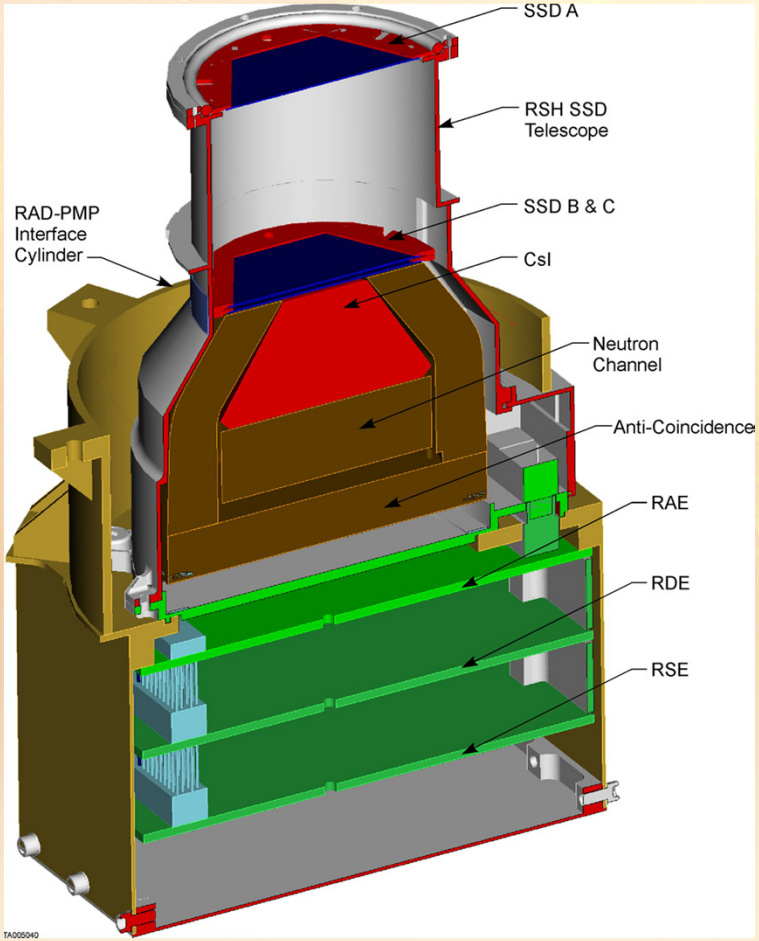
Thermal & Epithermal Neutron Detectors



Radiation Assessment Detector (RAD)

Principal Investigator: Donald M. Hassler

Southwest Research Institute



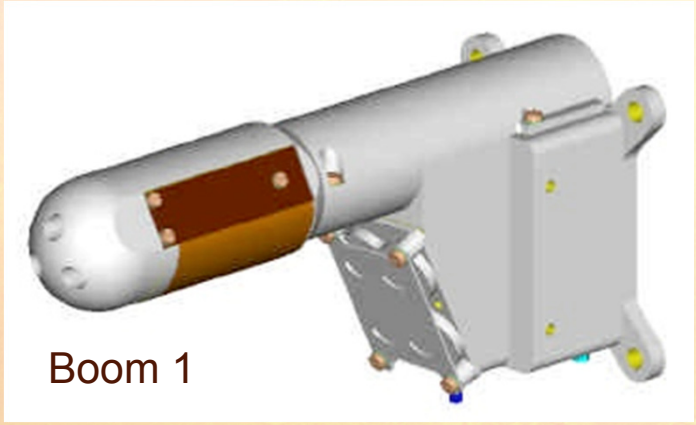
RAD characterizes the radiation environment on the surface of Mars

- Measures galactic cosmic ray and solar energetic particle radiation, including secondary neutrons and other particles created in the atmosphere and regolith
- Determines human dose rate, validates transmission/transport codes, assesses hazard to life, studies the chemical and isotopic effects on Mars' surface and atmosphere
- Solid state detector telescope and CsI calorimeter. Zenith pointed with 65º FOV
- Detects energetic charged particles (Z=1-26), neutrons, gamma-rays, and electrons

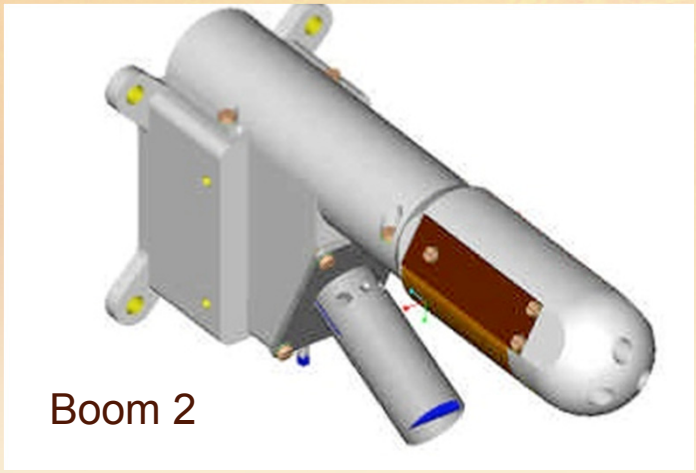
Rover Environmental Monitoring Station (REMS)

Principal Investigator: Javier Gómez-Elvira

Centro de Astrobiología (CAB), Spain



Boom 1

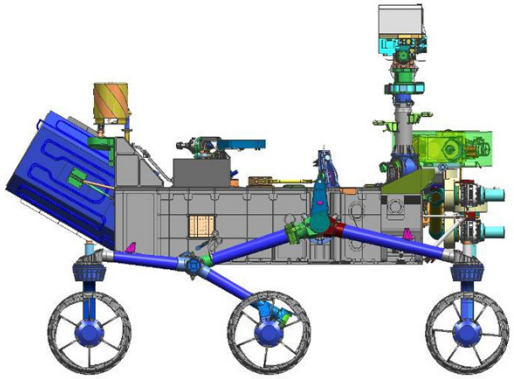


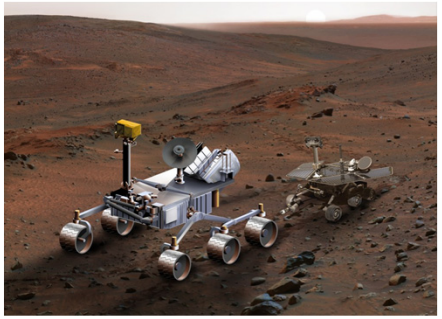
Boom 2

REMS measures the meteorological and UV radiation environments

- Two 3-D wind sensors
- Ground and air temperature sensors
- Pressure sensor
- Humidity sensor
- UV radiation detector (200 to 400 nm)
- 1-Hz sampling for 5 minutes each hour

Size Comparison





JPL 2009 MSL Rover